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(71) Applicant: SAMSUNG ELECTRONICS CO., LTD.
Suwon-city, Kyungki-do 441-373 (KR)

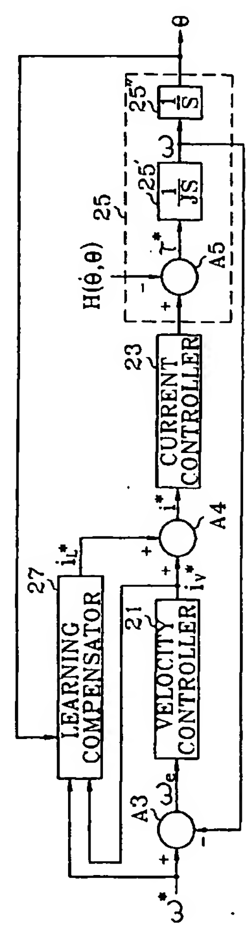
(72) Inventors:
- Seoung, Gan-soo
Seocho-gu, Seoul (KR)
- Kim, Young-hyn
Kwanak-gu, Seoul (KR)
- Ha, In-jung
Kwanak-gu, Seoul (KR)

(74) Representative: Chugg, David John
Appleyard Lees,
15 Clare Road
Halifax, West Yorkshire HX1 2HY (GB)

(54) Method for controlling velocity of rotary motor and apparatus therefor

(57) A velocity method for a rotary motor and an apparatus adopting the same, estimates and corrects a disturbance applied to the rotary motor to improve a velocity control characteristic, in which the disturbance is expressed as a function of an angular velocity and an angular position via a simple calculation process. The velocity control apparatus includes a learning compensator (27) for receiving a velocity command, angular position information and the output from a velocity controller (21) and correcting an effect of the disturbance which is expressed as a function of the angular velocity and the angular position, in addition to a general velocity control loop of a rotary motor composed of a velocity controller, a current controller, a motor and a velocity measuring unit. The learning compensator (27) stores one period of the output of the velocity controller (21) at the stable state of the velocity control loop and obtains a correction value using the stored value and the previous output value. Thus, the correction value obtained in the learning compensator (27) is stored in advance and a velocity control is performed using the stored value, to enable a simple and efficient velocity control.

FIG. 2



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Description

The present invention relates to a velocity control of a rotary motor contained in a video cassette recorder (VCR), and more particularly, to a velocity method for a rotary motor and an apparatus adopting the same, in which a disturbance applied to the rotary motor is estimated and corrected to improve a velocity control characteristic.

Since a disturbance exists usually in controlling a motor, an accurate motor control is not performed and a control error is generated. In this case, a VCR driven by the motor cannot perform a normal operation. Thus, such a disturbance is removed by estimating a torque of the disturbance of the motor by means of an observer. A control theory of suppressing such a load disturbance is being studied in a modern control theory. One example is shown in Figure 1.

Figure 1 is a block diagram showing a conventional velocity control apparatus of a rotary motor having a disturbance. The apparatus of Figure 1 is disclosed in a paper entitled "Autocompensation of Torque Ripple of Direct Drive Motor by Torque Observer" by Nobuyuki Matsui, Tatsuo Makino, and Hirokazu Satoh (IEEE Trans. on Industry Applications, vol. 29, No. 1, January/February 1993, pp. 187-194). In Figure 1, a first adder AI receives a velocity command ω^*_m as a reference input and motor 15 has an output response of angular velocity ω_m which is input to a negative input of AI so that AI obtains a difference $\omega^*_m - \omega_m$. The difference $\omega^*_m - \omega_m$ is input to a velocity controller 11. The velocity controller 11 outputs a current command i_v^* to control a rotational velocity of the motor 15 according to the input difference $\omega^*_m - \omega_m$. The current command i_v^* is input to a second adder A2. The second adder A2 adds the current command i_v^* applied from the velocity controller 11 and a disturbance removal command i_L^* and obtains a corrected current command i^*. Here, the disturbance removal command i_L^* is obtained by multiplying an estimation load disturbance torque $\hat{\tau}_L(i)$ estimated in a torque observer 17 which receives an angular velocity ω_m being an output response of the motor 15 and an actual current i by a transfer function K_T^{-1}. Here, values with the superscript * are actual values and values with the superscript * are command values. Meanwhile, the corrected current command i^* is input to a current controller 13. The current controller 13 expressed as the transfer function K_T supplies a torque command τ^* to the motor 15 in order to control a rotational velocity of the motor 15 in response to the corrected current command i^*. The motor 15 rotates at a speed corresponding to the torque command τ^* of the current controller 13. However, in controlling a motor, factors of regularly or irregularly varying a control quantity are generated according to peripheral conditions. Such factors are called disturbances T_L which chiefly bring about a difficult velocity control. Thus, a good velocity characteristic can be obtained when an effect of the disturbance is removed. The torque observer 17 which estimates the disturbance T_L applied to the motor 15 obtains an estimated load disturbance torque $\hat{\tau}_L(i)$ according to the following equation (1) under the assumption that the disturbance is varied sufficiently slowly.

$$\hat{\tau}_L(i) = \varepsilon(i) + L\dot{\omega}_m(i)$$

$$\varepsilon(i+1) = \hat{A}\,\varepsilon(i) + \hat{b}i_q(i) + \hat{k}\omega_m(i)$$

$$\hat{A} = 1 + LT_s/J_n,\ \hat{b} = -LK_{Tn}T_S/J$$

$$\hat{k} = L(L+D_n)T_S/J_n \qquad (1)$$

here, Jn, Dn and K_{Tn} are nominal values with respect to an inertial moment J, a damping factor D and a torque constant K_T. L which is smaller than Zero is an observer gain, ε is a random variable, $\hat{\tau}_L$ is an observer output, and T_s is a sampling period.

The above equation (1) can be defined as the following equation (2).

$$\hat{\tau}_L(S) = \frac{1}{1+ST}\tau_L(S) \qquad (2)$$

Here, τ_L is an actual load disturbance torque, $\hat{\tau}_L$ is an estimated load disturbance torque and s is a Laplacian operator. In this case, $T = -T_s/\ln(1+LT_s/J_n)$ and $1/(1+ST)$ plays a role of a low-pass filter. Here, values without a subscript n are actual values and values with the subscript n are nominal values which are designed to be close to the actual values.

Thus, if the actual load disturbance torque τ_L is slowly varied, it approximates the estimated load disturbance torque $\hat{\tau}_L$ to completely remove the load disturbance T_L.

As described above, the conventional method of removing the load disturbance by estimating the load disturbance torque of the motor requires much calculation time due to the complex equations and has substantial problems to implement it into hardware. Since a bandwidth of the low-pass filter 1/(1+ST) becomes large to follow up the fast varying

disturbances, the observer gain L should become large accordingly. The gain cannot be enlarged without limitation in an actual implementation, and the disturbance is estimated with respect to time. As a result, a continuous estimation operation should be performed during the operation of a closed loop with respect to the velocity control of the rotary motor, which results in much calculation.

With a view to solving or reducing the above problem, it is an aim of preferred embodiments of the present invention to provide a velocity control method for a rotary motor, which stores values for compensating an effect of a disturbance expressed as a function of an angular velocity and an angular position via a learning process and compensating the disturbance using the stored values.

It is another aim to provide a velocity control apparatus for a rotary motor, which implements a velocity control method for a rotary motor by estimating and compensating a disturbance via a repetitive learning control method.

According to a first aspect of the invention, there is provided a velocity control apparatus for a rotary motor, the velocity control apparatus comprising:

velocity measuring means for obtaining a velocity error by comparing an input reference velocity with an actual velocity detected from the motor;

a velocity controller for receiving the velocity error and outputting a current command for controlling the rotational velocity of the motor;

a learning compensator for receiving the input reference velocity and the current command output from the velocity controller and the angular position and for correcting an effect of the disturbance expressed as a function of an angular position and an angular velocity applied to the motor via a repetitive learning;

current command compensating means for obtaining a corrected current command by adding the current command output from the velocity controller and the disturbance correction value obtained in the learning compensator; and

a current controller for receiving the corrected current command and outputting a torque command to the motor.

Preferably, said learning compensator produces a periodic current command with respect to the periodic disturbance using the current command output from said velocity controller when the velocity control is in the normal state, and obtains a current disturbance correction value using one periodic value of the periodic current command and the disturbance correction value obtained in the previous learning.

Preferably, said learning compensator outputs the disturbance correction value based on the following equation,

$$i^*_{LK}(t)=i^*_{L(K-1)}(t)+mZ_{(K-1)}(t)$$

wherein i^*_{LK} is the disturbance correction value obtained in the K-th repetitive learning and becomes the output of the learning compensator, $i^*_{L(K-1)}$ is the disturbance correction value obtained in the (K-1)-th repetitive learning, m is the repetitive learning gain and m<1, $Z_{(K-1)}$ is one periodic value of the current command which is a periodic function output from the velocity controller in the (K-1)-th repetitive learning.

Said learning compensator preferably compares the current command output from said velocity controller with a predetermined threshold value and judges whether sufficient compensation is performed with respect to the disturbance applied to the motor, and if it is judged that sufficient compensation has been accomplished, the disturbance correction value is stored and the following disturbance correction is performed using the stored disturbance correction value in the following velocity control.

Preferably, said learning compensator obtains a new disturbance correction value via repetitive learning if it is judged that sufficient compensation has not been performed with respect to the disturbance applied to the motor.

Preferably, said learning compensator receives the input reference velocity and the angular position of the motor as addresses, and outputs the disturbance correction value stored in a position assigned by the addresses.

According to a second aspect of the invention, there is provided a velocity control method for a rotary motor, the velocity control method comprising the steps of:

(a) obtaining a velocity error by comparing an input reference velocity with an actual velocity detected from the motor;

(b) receiving the velocity error and outputting a current command for controlling the rotational velocity of the motor;

(c) receiving the input reference velocity, the current command and the angular position and outputting a disturbance correction value for correcting an effect of the disturbance expressed as a function of an angular position and an angular velocity applied to the motor via a repetitive learning;

(d) obtaining a corrected current command by adding the current command and the disturbance correction value;

(e) receiving the corrected current command and outputting a torque command to the motor; and

(f) detecting a present velocity of the rotating motor according to the torque command.

Said learning compensation step (c) preferably comprises the sub-steps of:

(c1) initializing the repetitive learning time into zero and the disturbance correction value into zero at the start of learning;

(c2) producing a periodic current command using the current command with respect to the disturbance which is a periodic function expressed as only an angular position with the constant angular velocity if the velocity control becomes the normal state via the step (b);

(c3) storing one period of the periodic current command;

(c4) increasing the repetitive learning times by one;

(c5) obtaining the current disturbance correction value according to the repetitive learning by adding the one periodic value of the periodic current command to the disturbance correction value obtained in the previous repetitive learning;

(c6) judging whether the disturbance is sufficiently compensated by comparing the current command in the step (b) with a predetermined threshold value at the time of correcting the disturbance applied to the motor with the obtained disturbance correction value;

(c7) storing the disturbance correction value if it is judged that the disturbance has been sufficiently compensated in the sub-step (c6); and

(c8) if the disturbance has not been sufficiently compensated in the step (c6), repeating the repetitive learning until the disturbance will be sufficiently compensated to thereby obtain the disturbance correction value.

Preferably, said learning compensation step (c) corrects the disturbance using the stored disturbance correction value.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

Figure 1 is a block diagram of a conventional velocity control apparatus for a rotary motor having a disturbance;

Figure 2 is a block diagram of a velocity control apparatus for a rotary motor having a disturbance according to an embodiment of the present invention; and

Figure 3 is a flowchart diagram for explaining the operation of the learning compensator in a velocity control apparatus of Figure 2.

A preferred embodiment of the present invention will be described below in more detail with reference to the accompanying drawings.

The Figure 2 apparatus is similar to the Figure 1 apparatus in view of the structure and operation thereof. In Figure 2, a learning compensator 27 is used instead of a torque observer. The learning compensator 27 receives a velocity command ω^*, the output of a velocity controller 21 and an angular position θ to produce an output i_L^* for correcting an effect of the disturbance.

The operation of the velocity control apparatus for a rotary motor according to the present invention will be described below with reference to Figure 3.

Figure 3 is a flowchart diagram for explaining the operation of the learning compensator 27 in a velocity control apparatus of Figure 2.

A first adder A3 compares a current velocity ω detected from a motor 25 with an input reference velocity ω^* and obtains a velocity error ω_e. The velocity ω_e is input to a velocity controller 21. The velocity controller 11 has the following equation (3) between the torque and the velocity with respect to the motor 25.

$$J\frac{d\omega}{dt} + T_L = T = K_T i \qquad (3)$$

Here, J is an inertial moment, ω is the number of the rotation, T_L is a torque of a load, T is an input torque, K_T is a torque constant, and i is a current of a coil.

If a load torque T_L is zero, the motor has no load disturbance. Thus, an excellent velocity control characteristic can be obtained using a general velocity controller. If there is a load torque T_L, the velocity control characteristic is lowered. In this invention, a learning compensator 27 has been proposed in which an effect of the disturbance $H(\dot{\theta},\theta)$ with respect to a load disturbance torque $T_L(H(\dot{\theta},\theta))$ expressed as a function of an angular position θ and an angular velocity $\dot{\theta}$ is removed via a repetitive learning. The learning compensator 27 receives the output i_v^* of the velocity controller 27, the velocity command ω^* and the angular position θ and produces the output i_{L^*} for removing an effect of the disturbance $H(\dot{\theta}, \theta)$ Here, the output i_L^* is a periodic function having a period T of $2\pi/\omega^*$ with respect to the velocity command ω^* and the time, and is defined as the following equation (4). In case of constant velocity control, $\theta=\omega^* t$.

$$i_{L(K)}(\omega^*,\theta)=i_{L(K-1)}(\omega^*,\theta)+mZ_{(K-1)}(\theta) \qquad (4)$$

Here, m<Kp, and Kp is a gain p of a velocity controller. Also, m is a repetitive learning gain, $Z_{(k-1)}$ is obtained by sampling an output of the velocity controller at normal state for a period T.

The above-defined periodic function represents convergence to a value for removing the disturbance $H(\dot{\theta},\theta)$. In the result of simulation, the disturbance $H(\dot{\theta},\theta)$ is removed from the output i_L^* of the learning compensator 27 via a few times of repetitive learning. The operation of the learning compensator 27 will be described in more detail with reference to Figure 3.

In Figure 3 if compensation starts, the learning compensator 27 initializes the number K of the repetitive learning into zero at the start, and the output I_L^* which is a disturbance correction value into zero, that is, K=0 and $i_L^*=0$ (step 301). Then, a general motor velocity control is performed only according to an existing velocity control loop (step 302). The general velocity control is performed until a velocity becomes a normal state (step 303). If the velocity of the motor being a control object becomes a normal state (step 303) via the velocity control step 302, the learning compensator 27 produces the current command i_v^* applied from the velocity controller 21 with respect to the periodic disturbance into a periodic current command, since it is a periodic function which is expressed as a constant angular velocity $\dot{\theta}$ and a disturbance $H(\dot{\theta},\theta)$ expressed as only the angular position θ (step 304). Also, one period of the periodic current command i_v^* is stored in the form of Z_K, that is, $(Z_K(t), t\in[0,T])$ (step 304). Then, the learning compensator 27 increases the repetitive learning times K by one, that is, K=K+1 and produces an output for correcting an effect of the disturbance by the following equation (5) (step 305).

$$i^*_{LK}(t)=i^*_{L(K-1)}(t)+mZ_{(k-1)}(t) \qquad (5)$$

That is, the disturbance correction value i^*_{LK} is obtained by the repetitive learning by adding a value by multiplying one periodic value $Z_{(k-1)}$ of the periodic current command stored via step 304 by the repetitive learning gain m, to the disturbance correction value $i^*_{L(k-1)}$ obtained in the previous repetitive learning. The learning compensator 27 takes the output i^*_{LK} of the above equation (5) as a final output i^*_L and outputs the final output to a second adder A4, that is $i^*_L=i^*_{LK}$ (step 306).

In Figure 2, the second adder A4 adds the current command i_v^* applied from the velocity controller 21 and the disturbance correction command i_L^* to output the corrected current command i^*. The current command i^* is input to the current controller 23. The current controller 23 outputs a torque command to the motor 25 in response to the input current command i^*. A third adder A5 in the motor 25 subtracts the applied disturbance from the torque command applied from the current controller 23, to output a corrected torque command τ^*. The velocity of the motor 25' expressed as a transfer function 1/JS is controlled according to the torque command τ^*. The angular velocity ω output from the motor 25 in the result of the velocity control is fedback to the first adder A3. A velocity error ω_e is obtained by subtracting

the angular velocity ω from the input velocity command ω^*. The velocity error ω_e is input to the velocity controller 21. The velocity controller 21 outputs the current command i_v^* for controlling the rotational velocity of the motor 25 according to the input velocity error ω_e. The current i_v^* is input to the learning compensator 27. The angular velocity ω is output as the angular position θ via the motor 25" expressed as a transfer function of 1/S, and is fedback to the learning compensator 27.

Returning to Figure 3, the learning compensator 27 which stores the disturbance compensation value obtained by the K-th learning compares the current command i_v^* input from the velocity controller 21 with a predetermined threshold value B, and judges whether the disturbance applied to the motor 25 is sufficiently compensated (step 307). In the disturbance compensation judgement step 307, if the current command i_v^* input from the velocity controller 21 is smaller than the predetermined threshold value B, that is, $i_v^*<B$, the learning compensator 27 returns step 302 to perform a general velocity control until it becomes a normal state. If it becomes the normal state, the learning compensator 27 repetitively performs processes of storing a value of the one period with respect to the output i_v^* of the velocity controller 21 and compensating the disturbance of the motor.

The learning compensator 27 recognises that sufficient compensation is performed if the current command i_v^* input from the velocity controller 21 is smaller than the predetermined threshold value B, and stores a periodic function i_v^* with respect to time as a final fixed correction value with respect to the disturbance (step 308). Then, the learning compensator 27 receives the input reference velocity ω^* and the angular position θ, and outputs the disturbance correction value stored in a position assigned by the addresses of a corresponding angle.

As a result, the velocity control is performed by simply adding the prestored correction value in the learning compensator 27 to the output i_v^* of the velocity controller 21, to thereby enable an efficient velocity control.

As described above, the velocity control method for a rotary motor and the apparatus thereof according to the present invention stores predetermined correction values for correcting an effect of the disturbance, and performs a velocity control using the stored predetermined correction values. Accordingly, a simple and efficient velocity control can be performed.

While only certain embodiments of the invention have been specifically described herein, it will be apparent that numerous modifications may be made thereto without departing from the scope of the invention.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A velocity control apparatus for a rotary motor, the velocity control apparatus comprising:

    velocity measuring means (A3) for obtaining a velocity error by comparing an input reference velocity with an actual velocity detected from the motor;

    a velocity controller (21) for receiving the velocity error and outputting a current command for controlling the rotational velocity of the motor;

    a learning compensator for (27) receiving the input reference velocity and the current command output from the velocity controller and the angular position and for correcting an effect of the disturbance expressed as a function of an angular position and an angular velocity applied to the motor via a repetitive learning;

    current command compensating means (A4) for obtaining a corrected current command by adding the current command output from the velocity controller (21) and the disturbance correction value obtained in the learning

compensator (27); and

a current controller (23) for receiving the corrected current command and outputting a torque command to the motor.

2. The velocity control apparatus for a rotary motor according to claim 1, wherein said learning compensator (27) produces a periodic current command with respect to the periodic disturbance using the current command output from said velocity controller (21) when the velocity control is in the normal state, and obtains a current disturbance correction value using one periodic value of the periodic current command and the disturbance correction value obtained in the previous learning.

3. The velocity control apparatus for a rotary motor according to claim 2, wherein said learning compensator (27) outputs the disturbance correction value based on the following equation,

$$i^*_{LK}(t)=i^*_{L(K-1)}(t)+mZ_{(K-1)}(t)$$

wherein i^*_{LK} is the disturbance correction value obtained in the K-th repetitive learning and becomes the output of the learning compensator (27), $i^*_{L(K-1)}$ is the disturbance correction value obtained in the (K-1)-th repetitive learning, m is the repetitive learning gain and m<1, $Z_{(K-1)}$ is one periodic value of the current command which is a periodic function output from the velocity controller in the (K-1)-th repetitive learning.

4. The velocity control apparatus for a rotary motor according to claim 3, wherein said learning compensator (27) compares the current command output from said velocity controller (21) with a predetermined threshold value and judges whether sufficient compensation is performed with respect to the disturbance applied to the motor, and if it is judged that sufficient compensation has been accomplished, the disturbance correction value is stored and the following disturbance oorrection is performed using the stored disturbance correction value in the following velocity control.

5. The velocity control apparatus for a rotary motor according to claim 4, wherein said learning compensator (27) obtains a new disturbance correction value via repetitive learning if it is judged that sufficient compensation has not been performed with respect to the disturbance applied to the motor.

6. The velocity control apparatus for a rotary motor according to claim 4, wherein said learning compensator (27) receives the input reference velocity and the angular position of the motor as addresses, and outputs the disturbance correction value stored in a position assigned by the addresses.

7. A velocity control method for a rotary motor, the velocity control method comprising the steps of:

(a) obtaining a velocity error by comparing an input reference velocity with an actual velocity detected from the motor;

(b) receiving the velocity error and outputting a current command for controlling the rotational velocity of the motor;

(c) receiving the input reference velocity, the current command and the angular position and outputting a disturbance correction value for correcting an effect of the disturbance expressed as a function of an angular position and an angular velocity applied to the motor via a repetitive learning;

(d) obtaining a corrected current command by adding the current command and the disturbance correction value;

(e) receiving the corrected current command and outputting a torque command to the motor; and

(f) detecting a present velocity of the rotating motor according to the torque command.

8. The velocity control method for a rotary motor according to claim 7, wherein said learning compensation step (c) comprises the sub-steps of:

(c1) initializing the repetitive learning time into zero and the disturbance correction value into zero at the start of learning;

(c2) producing a periodic current command using the current command with respect to the disturbance which is a periodic function expressed as only an angular position with the constant angular velocity if the velocity control becomes the normal state via the step (b);

(c3) storing one period of the periodic current command;

(c4) increasing the repetitive learning times by one;

(c5) obtaining the current disturbance correction value according to the repetitive learning by adding the one periodic value of the periodic current command to the disturbance correction value obtained in the previous repetitive learning;

(c6) judging whether the disturbance is sufficiently compensated by comparing the current command in the step (b) with a predetermined threshold value at the time of correcting the disturbance applied to the motor with the obtained disturbance correction value;

(c7) storing the disturbance correction value if it is judged that the disturbance has been sufficiently compensated in the sub-step (c6); and

(c8) if the disturbance has not been sufficiently compensated in the step (c6), repeating the repetitive learning until the disturbance will be sufficiently compensated to thereby obtain the disturbance correction value.

9. The velocity control method for a rotary motor according to claim 8, wherein said learning compensation step (c) corrects the disturbance using the stored disturbance correction value.

FIG. 1 (PRIOR ART)

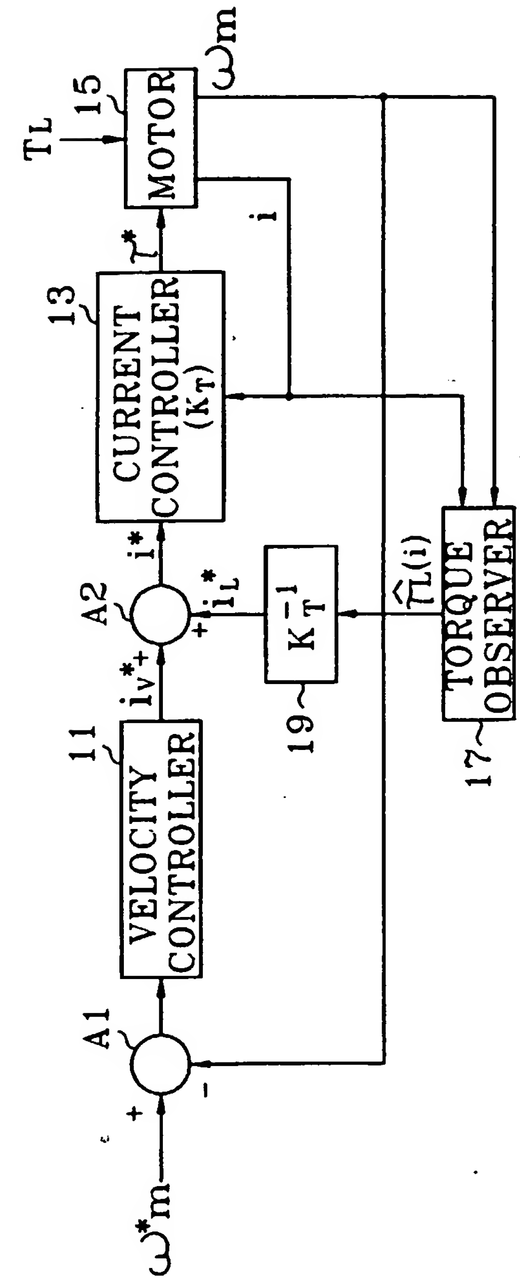


FIG. 2

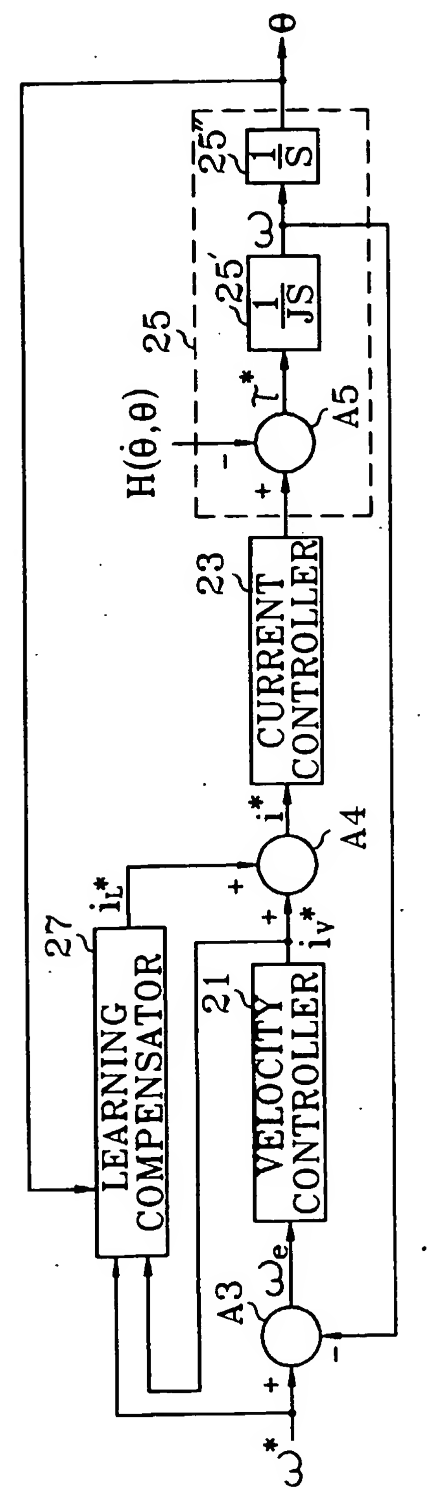
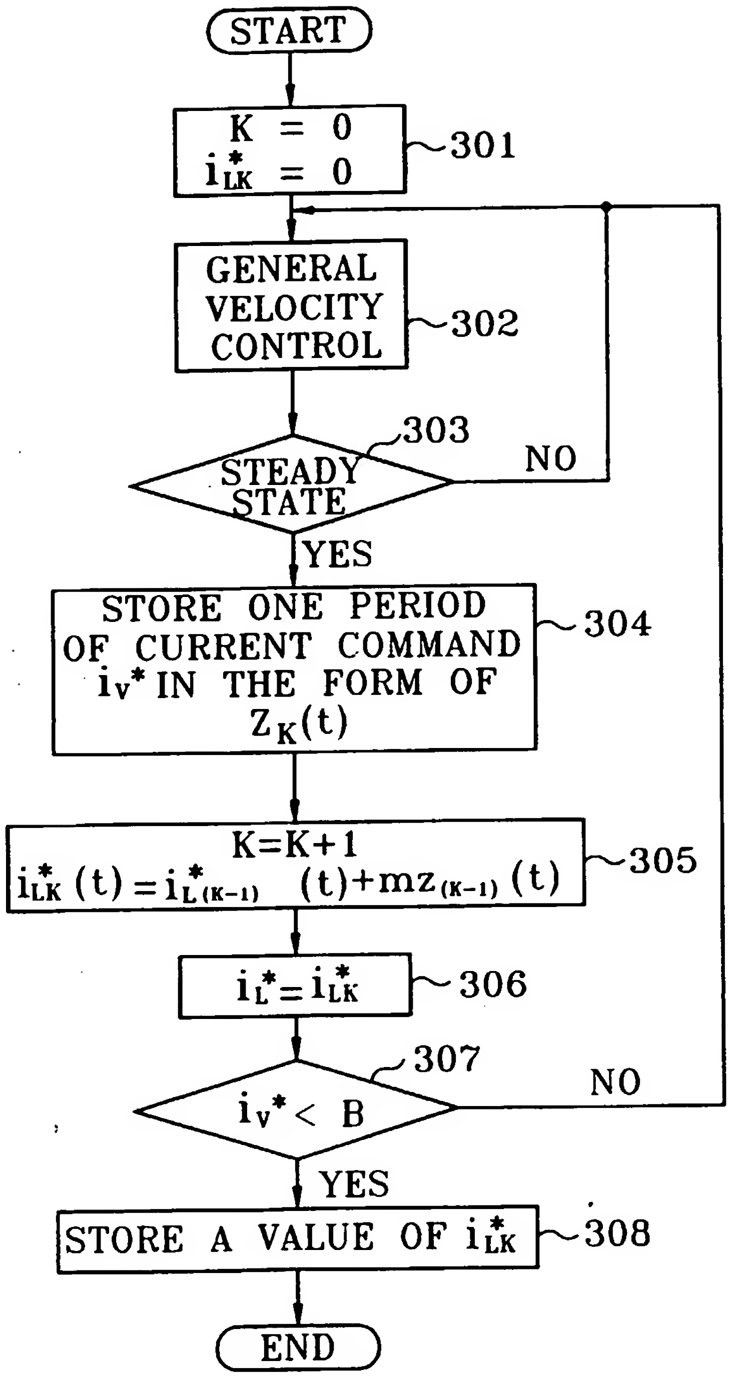

θ
25″
$\frac{1}{S}$
ω
25′
$\frac{1}{JS}$
25
τ^*
H(θ̇,θ)
+
-
A5
23
CURRENT CONTROLLER
i^*
A4
+
+
i_L^*
27
LEARNING COMPENSATOR
i_V^*
21
VELOCITY CONTROLLER
ω_e
A3
+
-
ω^*

FIG. 3


START
K = 0
i^*_{LK} = 0
301
GENERAL VELOCITY CONTROL
302
STEADY STATE
303
NO
YES
STORE ONE PERIOD OF CURRENT COMMAND i_V* IN THE FORM OF $Z_K(t)$
304
K=K+1
$i^*_{LK}(t)=i^*_{L(K-1)}(t)+mz_{(K-1)}(t)$
305
$i_L^*=i^*_{LK}$
306
$i_V^*<B$
307
NO
YES
STORE A VALUE OF i^*_{LK}
308
END

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 4869

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
D,A	IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, vol. 29, no. 1, January 1993, NEW YORK US, pages 187-194, XP000358881 NOBUYUKI MATSUI ET AL: "Autocompensation of Torque Ripple of Direct Drive Motor by Torque Observer" * the whole document *	1,7	H02P6/00
A	PATENT ABSTRACTS OF JAPAN vol. 17, no. 646 (E-1467), 30 November 1993 & JP-A-05 207776 (TOSHIBA CORP), 13 August 1993, * abstract *	1,7	
A	EP-A-0 469 151 (FANUC LTD) * abstract; figure 2 *	1,7	
A	EUROPEAN POWER ELECTRONICS CHAPTER SYMPOSIUM, 19 - 20 October 1994, LAUSANNE CH, pages 379-384, XP000603852 B.S. STEVENS: "THE COMPENSATION OF TORQUE VARIATIONS" * the whole document *	1,7	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H02P
A	US-A-4 561 400 (T. HATTORI) * abstract; figure 9 *	1,7	

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 October 1996	Beyer, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 4869

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	IROS'91, 3 - 5 November 1991, OSAKA JP, pages 647-654, XP000603848 M. GOTOU ET AL: "Development of Multirate Sampling Repetitive Learning Servo System and its Application to a Compact Camcorder" * the whole document * -----	1,7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 October 1996	Beyer, F

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A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

& : member of the same patent family, corresponding document

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